REMARKS

Claims 1-14 are pending herein.

I. Support for the amendments.

The amendment in claim 1 is based on original claim 12 and p. 38, lines12-19 of the original specification. The amendment in claims 9 and 10 are based on a paragraph bridging pages 14-15. Thus, no new matter has been introduced.

II. The anticipation rejection of independent claim 1 in view Hotomi.

In the Office Action, claims 1-3, 6 and 8-12 are rejected under 35 USC 102(e) as being anticipated by Hotomi (US 5,477,249).

The applicant has amended claim 1 to further limit the nozzle diameter to not more than 8 μm.

In the invention, it is intended to induce electric field concentration effectively by minimizing the nozzle diameter. On the other hand, Hotomi teaches neither calimed the nozzle diameter of not more than 8 μm nor structurally inherent effect of the electric field concentration.

The following is an example of the effect of the electric field concentration, and demonstrates that the maximum electric field intensities in the condition where nozzle diameter is 8 μm and jetting voltage applied between the nozzle and the counter electrode is 200 v, and distance from the nozzle to the counter electrode (gap) is 100 μm, which are also shown in the chart in Fig. 7 of the present specification.

5.10196×10^7 V/m (gap: 100 μm)

5.005×10^7 V/m (gap: 2000 μm)

Such high electric field intensity can be obtained because the electric field is concentrated to the convex meniscus formed by the liquid solution at the nozzle edge portion. In contrast, the following is electric field intensities in a normal parallel electric field where 200 V voltage is applied, which are calculated as dividing voltage with gap distance.

2.0×10^6 V/m (gap: 100 μm)

1.0×10^5 V/m (gap: 2000 μm)

As shown above, the present invention is successful in utilizing much larger effect of electric field than in the case of normal electric field.

Specifically, electrostatic force to jet a droplet is about 25 folds larger in the case of 100 μm gap, and is about 500 folds larger in the case of 2000 μm gap. Generally, it is required to apply high voltage of several kV in order to jet a droplet fly only by electrostatic force in normal condition.

However, according to the invention, it becomes possible to jet a droplet with fairly low voltage of several hundreds V. That is, it becomes possible to jet a droplet by remarkably lower energy than in normal condition.

Furthermore, as seen in the above example, when the nozzle diameter is 8 μm or less so as to make electric field concentrate, the maximum electric field intensity is hardly affected by a gap distance. Thus, the present invention is advantageous in stable jetting of droplets (also see Fig. 7).

Since an effect of electric field concentration is utilized, the present invention is successful in jetting droplets from a nozzle whose nozzle diameter is too small to jet droplets only by vibration energy of a piezoelectric vibrator. Thus, it becomes possible to attain ink-jet printing with smaller droplets.

Next, claim 1 also has been amended to limit the jetting voltage within the claimed range. The claimed voltage range is such that a droplet can be firstly jetted in a stage where the liquid solution protrudes from the edge portion of the nozzle by the action of the convex meniscus forming section, and a droplet can not be jetted in a state where the convex meniscus is not formed since electrostatic force caused by the applied jetting voltage is not enough.

To jet droplets, a function required to the convex meniscus forming section is only to form and not to form a convex meniscus. It is not necessary that the convex meniscus forming section applies such large force to the liquid solution that a droplet is jetted only by the force. That is, the convex meniscus forming section requires only low energy to activate.

Furthermore, it is possible to control jetting of droplets only by controlling activation of the convex meniscus forming section.

On the other hand, Hotomi discloses as follows on column 4, 1ines 47-54: "The ink does not reach the recording paper 16 when jetting force does not work for lack of vibrational energy or electrostatic attraction force does not work for lack of electrostatic energy. Thus, both vibrational an delectrostatic energy are required to be applied at the same time for the ink to jet." Although disclosed is a combination of vibration energy and electrostatic energy, Hotomi is silent to the jetting voltage within a range where ink is jetted according to presence or absence of a convex meniscus.

As described above, Hotomi does not disclose the claimed nozzle diameter and jetting voltage range of the invention. Thus, the claimed invention is totally distinct over Hotomi, and is not anticpated by Hotomi obvious for a skilled person over any references cited by the Examiner.

The amendment in claims 9 and 10 is to limit the insulating property of the nozzle or the edge portion of the nozzle to dielectric breakdown strength of 10 kV or more, so as to clarify the insulating property. None of Hotomi and the other references teaches or suggests such insulating property either.

In view of the foregoing, the amended claims are patentable over the prior art, and the present application now stands for allowance.

III. Claims Withdrawn.

Claims 4, 5 and 7 are withdrawn.

IV. Conclusion.

Reconsideration and allowance of all of the claims is respectfully requested.

If there are any additional charges with respect to this Amendment or otherwise, please charge them to Deposit Account No. 06-1130.

Please contact the undersigned for any reason. Applicants seek to cooperate with the Examiner including via telephone if convenient for the Examiner.

Respectfully submitted,

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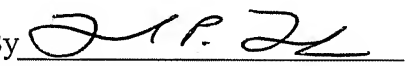
By 

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